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IRRIGATION AND DRAINAGE PROBLEMS IN HAITI

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IRRIGATION AND DRAINAGE PROBLEMS IN HAITI*

George H. Hargreaves,[1] A.M. ASCE

SYNOPSIS

Water resources are presently less well developed in Haiti than they were one hundred and fifty years ago. Periods of low rainfall varying from 6 to 12 months of the year for the plains areas combined with high water table conditions in many areas make irrigation and drainage necessary for improving crop production. Power is needed for helping finance irrigation, for ground water pumping, for industry and for stimulating agricultural processing.

Present conditions, future possibilities and the required studies and investigations are discussed. The Artibonite Project for the development of 38,400 kilowatts of electrical energy and the irrigation of 85,000 acres of fertile valley lands is described. This paper presents some of the problems encountered in water resource development in Haiti.

INTRODUCTION

Irrigation and drainage were well developed in the coastal plains of Haiti during the French colonial period. The systems were well located and of good design. Much developmental work can now be accomplished by restoring colonial canals and drains.

Some idea as to the history of irrigation can be had from developments in the Cayes-Torbeck Plain which is fifth in size of the coastal plains of Haiti and comprises approximately 50,000 acres. Irrigation commenced in 1761 when Riviere de l'Acul was diverted for irrigation. In 1770 a diversion for irrigation was established from La Ravine du Sud near Camp Perrin. Water from these rivers and from smaller streams was used both for irrigation and for operating mills for the extraction of sugar. It is reported that about fifty per cent of the plain was under irrigation systems during the colonial period.[2]

After Haiti won its independence from France in 1804 the organizations for administering these irrigation and drainage facilities disappeared and the facilities rapidly deteriorated. By 1949 little land within the plain was actually being irrigated. In 1939-41 two small irrigation systems were built in the Cayes-Torbeck Plain. These systems were well designed and constructed but were not used until irrigation was stimulated through a program of land development commencing in 1952.

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* Presented at Salt Lake City Meeting, ASCE, Sept. 9-11, 1954.

1. Civ. Engr., The Institute of Inter-American Affairs, Foreign Operations Administration, Port-au-Prince, Haiti.

2. Moreau de Saint-Mery, L.E., Description Topographic, Physique, Civile et Politique de la Partie Francaise de l'Ile Saint Domingue, 2 Volumes, Philadelphia 1797-98.

Starting in 1951 the Service Cooperatif Interamericain de Production Agricole (SCIPA), an agency jointly staffed and financed by The Institute of Inter-American Affairs (IIAA)[3] and the Haitian Department of Agriculture, started the rehabilitation of existing irrigation facilities in the area. Presently, about 2,000 acres are reported to be under irrigation and the principal engineering features are available for the irrigation of a much larger area.

In the Leogane, Cul-de-Sac and Arcahaie plains irrigation facilities constructed by the French are still in use. The irrigated areas have decreased somewhat since the colonial period. In the North, irrigation has not been well developed. In the Limbe Plain, however, important irrigation facilities and a network of drains were established by the colonists. These were partially restored in 1939-41 but are presently unusable due to flood damages and a lack of maintenance.

After the colonial period cultivation of steep slopes for the production of food crops, principally corn and grain sorghums, increased rapidly. Flood damages increased and due to the increased erosion and the building up of meandering stream ridges on the plains and the lack of maintenance of the colonial drains, drainage problems became more acute.

Through developing power and stimulating industries, opportunities can be created for people to move off of badly eroded areas. Power revenues are needed to help finance the construction of irrigation and drainage facilities, for the development of several areas by pumping from ground water for irrigation and drainage and for the processing of agricultural products.

Need for Irrigation, Drainage and Power

Rainfall differences are great in the various parts of Haiti. Along the southern coast of the northern peninsula rainfall averages about 20 inches or somewhat less. Data are not available for many portions of the country. However, for a portion of the southern peninsula precipitation is known to be considerably in excess of 100 inches annually.

Due to the distribution of rainfall total quantities give little indication of irrigation needs. It is frequently torrential with wide departures from normal. In the Artibonite Valley rainfall varies from 28 inches along the seaward margin of the plain to 56 inches in the upper or eastern margin of the plain. Approximately 85 per cent of the mean annual rainfall occurs during the May through October wet season.

In determining needs for irrigation, consideration must be given to wide fluctuations in rainfall such as from 0 to 4.1 inches during March and from 3.1 to 23.8 inches during July at Petite Riviere in the Artibonite Valley. Because of wide deviations from normal, it is assumed that not more than fifty per cent of the mean monthly rainfall is dependably available for meeting consumptive use requirements. This assumption has also been checked by comparing monthly consumptive use requirements with monthly rainfall data month by month over a period of several years.

Sugarcane is one of the important crops in Haiti. Its consumptive use of water has been measured under similar climatic conditions in Puerto Rico. Assuming an efficiency of fifty per cent, irrigation seasons have been computed for sugarcane by making allowance for utilizable rainfall. Irrigation seasons for the important plains of Haiti are given in Table 1.

3. IIAA is now the Latin American operations branch of the Foreign Operations Administration.

Irrigation seasons vary considerably. For the Cayes-Torbeck Plain sugarcane should normally be irrigated November through March and during July. In the Plain du Nord it should normally be irrigated during January, March and June through September and in several plains it should be irrigated throughout the year.

Along the seaward margins of most of the coastal plains, drainage conditions are poor. During the rainy season the water table rises to within a few feet of the surface and areas of outflow and standing water are frequent. Several poorly drained areas are strongly saline. Soils of the poorly drained areas generally range from silty clay loams through silty clays with some important areas of heavy clay. They are usually calcareous and maintain open permeable structures. Calcium is generally abundant in the irrigation waters. Since the replacement of sodium ions is nearly quantitative under these conditions, reclamation will proceed rapidly where good drainage can be provided.

The total installed electrical capacity in Haiti is about 18,000 kilowatts of which more than one third is generated directly by the consumers. Power shortages are frequent and power market studies indicate possibilities for a rapid load growth.

Studies have been made of ground water conditions in several of the important plains.[4] In the Cul-de-Sac Plain the Haitian American Sugar Co. (HASCO) is pumping water for the irrigation of more than 5,000 acres, and it is estimated that the area can be increased by an additional 10,000 acres. In the Gonaives Plain an estimated 5,000 acres can be irrigated by pumping. Approximately 4,000 acres in the Arcahaie Plain and 10,000 acres in the Cayes-Torbeck Plain can probably be irrigated by pumping from ground water. Other areas have been less thoroughly investigated, but enough information is available to indicate that ground water development can be of major importance in many of the plains of Haiti. An increase in power available to these areas will not only provide marked irrigation benefits but also by lowering the water table will improve drainage conditions.

Present Status of Irrigation and Drainage

Although data are not available on areas actually irrigated, the Department of Public Works is administering irrigation systems serving approximately 125,000 acres. Taxes collected from irrigation assessments total about $100,000 annually. Most of this is spent to pay operating personnel. Only a small portion is used for maintenance. SCIPA is presently operating and maintaining projects irrigating a total of approximately 4,000 acres and the Organisme de Developpement de la Vallee de l'Artibonite (ODVA) has about 9,000 irrigated acres under its control in the Artibonite Valley.

Drainage problems are of considerable magnitude in most of the important plains of Haiti. Except for the Artibonite Valley, the only important drainage network is in the Cul-de-Sac Plain. This is far from adequate and much additional drainage is required both because of the high water table and the associated saline conditions. Small drainage networks have been constructed by SCIPA in several areas.

Irrigated tracts are small. For 26 small projects totaling 24,826 acres ownerships vary in size from less than an acre to 125 acres with a total of

4. Nine reports on ground water in various parts of Haiti prepared in 1949 by George C. Taylor, U.S. Geological Survey and Remy C. Lemoine, SCIPA.

8,025 water users irrigating an average of 3.1 acres per user. Irrigation from small rivers is generally poorly organized. In many places small streams serve as main canals with as many as twelve or fifteen openings in the bank per mile serving as uncontrolled intakes for irrigation. Rivers are frequently checked by brush dams which, with the high rates of erosion, cause the river channels to silt up during floods increasing drainage problems by flood irrigation and by creating stream ridges that sometimes cut off lower lying lands from their former drainage outlets.

Although an Arrete of March 17, 1953, provides a sliding scale of taxes based upon the number of liters per second per hectare delivered, water is not measured on the various irrigation systems. HASCO keeps good records on the quantity of water pumped from the various wells but makes no attempt to correlate water pumped with crop requirements.

Irrigation efficiencies are very low. Sugarcane is largely furrow irrigated and some rice has recently been irrigated through the efforts of SCIPA by the contour check method. Other crops such as beans, vegetables, bananas, corn, tobacco, grain sorghum, etc. are irrigated by filling small irregularly shaped basins with water or sometimes by wild flooding. The lands have traditionally been prepared for irrigation almost entirely by use of hoes. SCIPA has recently (in 1952) started a program of expanding and improving irrigation through land preparation by mechanical means as well as by animal drawn tools and has installed measuring devices at a few locations.

Irrigation and Drainage Possibilities

Except for the Artibonite Project, little study has been made of the water resource development possibilities since a report was prepared in 1927.[5] Topographic maps of a scale of 1:50,000, prepared by the U.S. Army Map Service, are available for a portion of Haiti. However, large and important areas have not as yet been mapped. Little stream flow data have been collected since 1939 and rainfall data are insufficient for drawing an accurate isohietal map. Based on the available information, some of the more important possibilities are briefly described. As more information becomes available other possibilities will undoubtedly be found.

Cayes-Torbeck Plain

The Cayes-Torbeck Plain, comprising about 50,000 acres, offers one of the most advantageous opportunities for irrigation development. Improvement of the d'Avezac canal system, a diversion dam on Riviere de l'Acul, numerous diversions for irrigation in the Torbeck plain and construction of the drainage and distribution systems are required. About 17,000 acres can be given a full irrigation supply without reservoir storage. Storage sites are available but require further study to determine their feasibility.

Topographic maps of a 10 meter interval at a scale of 1:50,000 are available. For a portion of the plain, mapping at a 1 meter interval has been accomplished. Presently SCIPA is starting on a cooperative program with the Inter-American Geodetic Survey (IAGS) for the mapping of the entire plain at a 2 meter interval. As the average slope is about 10 meters per kilometer, this interval will give good coverage for irrigation and drainage planning. Stream flow measurements are available for a period of eleven years for Ravine du Sud. Much gauging of other streams and some further measurements of rainfall are required for development planning.

5. Republic of Haiti, Bureau of Public Works, Report on Irrigation Possibilities in the Republic of Haiti, Port-au-Prince, 1927.

Trois Rivieres Project

It is proposed that a dam be constructed on Trois Rivieres to provide 80,000 acre feet of storage for the irrigation of 20,000 acres and the generation of 2,300 kilowatts of power. An important feature of this proposal is that an estimated 5,000 acres in the Gonaives plain can be irrigated by ground water pumping. As the ground water is at shallow depths in much of this area, pumping will improve drainage conditions.

Topographic maps of a scale 1:50,000 are available and maps of a one meter contour interval have been prepared for a part of the Gonaives Plain. The river has been gauged for a period of fifteen years. Further study should include detailed topography of the dam and reservoir sites, of the proposed canal locations and of additional portions of the service area.

Other Irrigation Possibilities

Some of the other important irrigation development proposals are summarized as follows:

Project	Area to be Irrigated
Leogane Plain - Momance Reservoir	** 25,000 Acres
Riviere Grise - Cul-de-Sac Plain *	** 15,000 "
Grand Riviere de Nippes *	18,000 "
Grand Riviere du Nord	11,000 "
Limbe Plain	6,000 "
Maribaroux Plain	9,000 "

The Artibonite Project

The Artibonite river is the only large river in Haiti. It drains an area equal to about one third of the total land area of the Republic. During the French colonial period a system of levees was constructed in the Artibonite Valley along the Artibonite and Estere Rivers. Some important canals were built and drains were provided in the lower plain. Much of the work has been destroyed by floods or abandoned due to lack of maintenance under the system of small ownerships which has prevailed since the fragmentation of the French plantations after Haiti won its independence. Important facilities are, however, still in use. Normally about 24,000 acres are devoted to rice production. An important portion of this area depends upon colonial canals and levees to deliver and retain flood waters for the lands.

The first study for a large irrigation project was made by the French more than two centuries ago. In 1926 a soil survey of the Artibonite Plain was published[6] and in 1927 a study of the irrigation possibilities was included in the report prepared by the Bureau of Public Works. In June 1948, SCIPA presented a plan for the flood control, irrigation and drainage of the Artibonite Valley. SCIPA operation of a pilot project at Villard demonstrated the feasibility of the reclamation of saline lands. Because of this report, the

6. Report on the Soil Survey of the Artibonite Plain, Service Technique of the Department of Agriculture and Vocational Education, Bulletin No. 5.

success of the Villard irrigation project and subsequent attempts on the part of the Haitian Government to finance the development, the firm of Knappen-Tippetts-Abbett-McCarthy, Engineers of New York was hired to prepare a study and report which was presented in June 1950.[7]

A loan of $14,000,000 was negotiated with the Export-Import Bank of Washington and in December 1952 a contract was let with Brown & Root of Houston, Texas. During 1952 the IIAA furnished a team of technicians to work with the Organisme de Developpement de la Vallee de l' Artibonite (ODVA). This group together with technicians assembled by Board of Administration, ODVA, constituted the ODVA Planning Group for the preparation of a development program.[8] The IIAA is now furnishing two technicians to assist in the planning and development work now being carried out in the Valley and has made plans for furnishing six more as soon as they can be recruited.

Principal Project Features

The Peligre Dam is under construction in a narrow canyon about thirty-seven miles from the head of the Plain. The massive head buttress dam, with an overall heighth of 231 feet from foundation to roadway, is the highest of its type in the Western Hemisphere. The reservoir with an area of 77,500 acres has an active storage capacity of 266,000 acre feet. Although not yet financed, a power house is planned with three 12,800 kilowatt generating units.

At the head of the Plain, the Caneau Intake is being constructed to divert water into a main Left Bank Canal and a smaller Right Bank Canal. In addition to the storage in Peligre Reservoir, flood control is provided by a by-pass floodway and improvement of the Estere River channel. This latter serves as a principal drain into which the main drainage channels empty.

Presently it is planned to serve an area of 85,000 acres with a network of canals totaling 270 miles. There are, however, 15,800 acres of salt flats along the seaward margin of the project and additional areas of lands north of the Estere River which will be included in the total development. Also there is an area exceeding 16,000 acres of mangrove swamps, portions of which will be cleared and reclaimed for rice production as development progresses.

Present Conditions and Problems

The Project includes about 4,300 acres irrigated from the Villard system and 17,200 acres of rice lands irrigated principally from flood and drainage waters. In addition there are several small irrigation systems along the margin of the plain. About 22,000 acres normally, during the May through October rainy season, produce good crops, principally of corn and grain sorghum. The remainder of the area is largely marginal or non productive, a considerable portion of which is presently covered with brush.

The drainage area of the Artibonite Basin is 3,550 square miles of which 2,480 lie within Haiti, the remainder being within the mountains of the Dominican Republic. The alluvial plain of the Artibonite, comprised of recent alluvial soils, has an area of 140,000 acres. The Central Plateau in the upper part of the Basin covers an area of about 500,000 acres. The Haitian part of the Basin has a population density of 355 per square mile. The Plain under present conditions supports approximately 528 inhabitants per square mile. The modal size farm is about three acres.

7. Engineering and Economic Report, Artibonite Valley Development for Irrigation, Flood Control, Drainage and Hydroelectric Power.
8. Plan and Program for Development of the Artibonite Valley, Organisme de Developpement de la Vallee de l'Artibonite, ODVA Planning Group, Sept. 1952.

Approximately ninety five per cent of the inhabitants of the Valley are illiterate. In the rural areas of the Basin about three per cent of the population are enrolled in schools. Although health problems are of major significance, health facilities are limited, there being approximately 180 hospital beds in the Basin.

The Artibonite Basin is characterized by a lack of good roads. Most goods move to markets over trails on the heads of women and the backs of pack animals. This isolation contributes to the lack of economic development and progress.

Roughly the lower half of the Plain is affected by a high water table and varying degrees of salinity. Exchangeable sodium frequently runs as high as 13 in the soils. Fortunately the irrigation water is of excellent quality, analyses indicating a range of total dissolved solids of from 185 to 370 parts per million and a sodium percentage of from 5 to 16. As the irrigation waters are high in calcium, sodium will be rapidly removed from the soil under irrigation. Open permeable structures will be maintained favoring reclamation and drainage.

The Standard Fruit Company developed a total of 4,400 acres in the upper Plain to bananas. This enterprise was abandoned in 1953. Among the important reasons for the abandonment were wind storms, inability to lease a sufficiently large area and drainage problems. The rise in the ground water levels resulting from irrigation required the establishment of elaborate drainage networks. These only partially solved the problems and yield and quality of fruit remained low. Considerable improvement was, however, made during World War II when due to the difficulties involved in obtaining fuel to pump water from the river, irrigation was materially reduced.

Because of the saline conditions and the low elevations above sea level it is anticipated that the lower plain will be devoted to the production of rice. Much of the upper Plain appears ideally suited for general crops if provision can be made to keep ground water levels from rising too near the surface. Although an adequate supply of water will become available, it may be desirable to integrate development of this area with ground water pumping. If suitable water bearing strata can be found, ground water pumping could probably lower the water table and solve drainage problems.

Power Development and Project Repayment

The estimated construction cost is about $25,000,000. Other capital costs including land preparation, operating loss during development and interest on the loan are estimated at about $13,000,000, with a total capital cost of about $38,000,000. Assuming a nine year development period and an irrigation tax of $16 per acre, net revenues over and above estimated project operation and maintenance total about one third of the total capital costs during the estimated 50 year useful life of the project works.

On the other hand, the incremental costs of power development are estimated at $7,400,000 with a total estimated cost chargeable to power of $8,730,000 (cost data of May 1952). This latter amount can, based on a very conservative power market analysis, be paid out with 4 per cent interest in 22 years and return a profit during the remaining 28 years totaling $47,000,000.

The development of an enlarged, stable, more diversified agriculture depends in a large measure upon the stimulation of processing facilities through making power available. Also, because of the low educational level the population is acutely lacking in technical knowledge and in the means to acquire such knowledge. A rural electrification program in the Plain would

be a great stimulus toward educational advancement.

The Central Plateau

The Central Plateau, comprised of lake deposits of Miocene age, was captured as part of the drainage basin by headward cutting of the Artibonite River. The principal tributary streams have cut deeply into the former lake sediments. Erosion is continuing at a very rapid rate over most of the area. Recent alluvial deposits from the Artibonite River have built up the fertile Artibonite Plain and crowded the Estere River to the northern edge.

The Plateau is used principally for grazing. During the rainy season growth of grass is luxuriant; however, during the long dry season the grass becomes dry and unpalatable. Fires are started in order to remove coarse grasses and prevent encroachment of brush and trees. After burning a short growth usually reoccurs and is heavily grazed adjacent to the streams. At the beginning of the rainy season erosion is particularly rapid.

Topographic maps are not available for the Central Plateau and stream flow measurements are available for only one of the six streams of major importance which traverse the area. At least three dam and reservoir sites appear suitable and large areas of good soils are available for irrigation development.

Investigation of the Central Plateau is of particular urgency because of the silt carried by the Artibonite River. Based on available silt sampling data, it is estimated that should all the silt be deposited in the reservoir, forty per cent of the storage capacity will be lost in a fifty year period. Most of this silt comes from the Central Plateau. As the area is now used for livestock grazing important features of a program of conservation should include development of irrigated pastures, construction of stock water facilities and a general program of range management.

Principal Factors Retarding Development

Well trained engineers are available in Haiti for the construction of good facilities for irrigation, yet water resources are presently less well developed than they were one hundred and fifty years ago. Many factors combine to create this situation.

Frequent Cabinet changes and the urgency of other problems have prevented long range development planning. Water resources development has further been discouraged by the decline, failure or lack of use of many well constructed projects. It appears that good administration, adequate land development and good maintenance of project facilities are more important to success than the construction of good engineering facilities. Good administration in turn depends upon the development of greater participation of the water users, the development of higher educational levels and a basic knowledge of the principles of irrigation.

Water Law and Water Rights

An Arrete of March 17, 1953, gives rural lands a right to water proportionally to the area and fixes the water right with the land. This law prohibits a land owner from taking water without authorization from a qualified representative of the irrigation service. Stream flow is greatest during the periods of lowest requirements for irrigation. During periods of high run-off, the irrigated areas frequently expand. Once authorized to take water, the law gives a user the same right to water proportionally to his area as users with long established rights. During periods of drought and during dry seasons

water is sometimes delivered to so large an area that none of it has enough for a crop.

Improvement in this should be made by developing a knowledge of the factors relating to irrigation and through the correlating of soil moisture requirements for various crops with available water supplies. When such knowledge has been developed then perhaps steps should be taken to give some lands under a given system a year around supply of water, while limiting irrigation on other lands to the rainy season only.

Irrigation Taxes

Probably the most common causes of failure on irrigation projects are:

1) Waste of water due to inadequate control of water deliveries and sources of supply.
2) Ignorance of irrigation practices and soil moisture requirements for good crop production.
3) Inability to raise the necessary funds for good operation and maintenance of project facilities.

Not only will a good tax policy provide the necessary funds, but it frequently is an important educational means of teaching the proper use of irrigation water.

A law of September 20, 1952, provides an irrigation tax proportional to the area cultivated and the quantity of water delivered with a minimum tax of eighty one cents per acre per year. The Arrete of March 17, 1953, sets up a sliding scale of irrigation taxes ranging from 81 cents to $10.12 per acre. Since water is not measured, the agency collecting the tax would appear to be placing itself in jeopardy from a legal point of view whenever it collects more than the minimum tax.

CONCLUSIONS

Because of the density of population and the pressing needs for additional food supplies as well as the needs for enterprises other than agriculture, irrigation, drainage and power development should receive high priority in the budgeting of the limited funds available for expenditure by the Republic of Haiti. Irrigation and drainage are of primary importance for agricultural development. However, an enlarged more diversified agriculture will be unprofitable without new processing, storage, marketing and transportation facilities.

Presently an important portion of the National revenue is derived from taxes levied on the export of coffee. Food crops compete to a large degree with coffee on lands best suited for coffee production. Increased food supplies produced on irrigated areas in the plains will free mountainous lands for coffee production and for other crops which will provide revenues and conserve the soil thereby reducing problems caused by a fairly high rate of erosion and increased flood peaks. At the same time increased production will result in greater national income and increased tax revenues.

Although irrigation development in the Artibonite Valley fails to be self liquidating from possible irrigation taxes, there will be many indirect benefits such as increased revenue from exports and imports. When considered in its full scope with power included this project is conservatively estimated to have possibilities of repaying all capital and operating costs and in addition yielding a profit of in the order of $22,000,000 within a fifty year period.

ACKNOWLEDGMENT

The author is indebted to the Service of Irrigation, Hydroelectricity and Hydrology of the Department of Public Works and members of the staff of SCIPA for information, review and helpful comments. The ODVA Planning Group report, footnote No. 8 is the principal reference for data concerning the Artibonite Project.

TABLE 1

IRRIGATION SEASON FOR IMPORTANT PLAINS

Plain	Approximate Area	Irrigation Season
Central Plateau	500,000 Acres	7 - 8 Mo.
Artibonite Plain	140,000 "	9 - 12 "
Cul-de-Sac Plain	80,000 "	11 - "
Plain du Nord	65,000 "	6 - "
Cayes-Torbeck Plain	50,000 "	6 - "
Maribarouz Plain	40,000 "	7 - 8 "
Leogane Plain	25,000 "	9 - "
Gonaives Plain	20,000 "	12 - "
Aquin Plain	17,000 "	8 - "
Arbre Plain	16,000 "	12 - "
Arcahaie Plain	16,000 "	12 - "
Limbe Plain	9,000 "	6 - "
Miragoane Plain	8,000 "	9 - "
Region de Port-de-Paix	8,000 "	11 - "

FIG. I

MAP OF HAITI
ARABLE PLAINS

SCALE 1/1900000

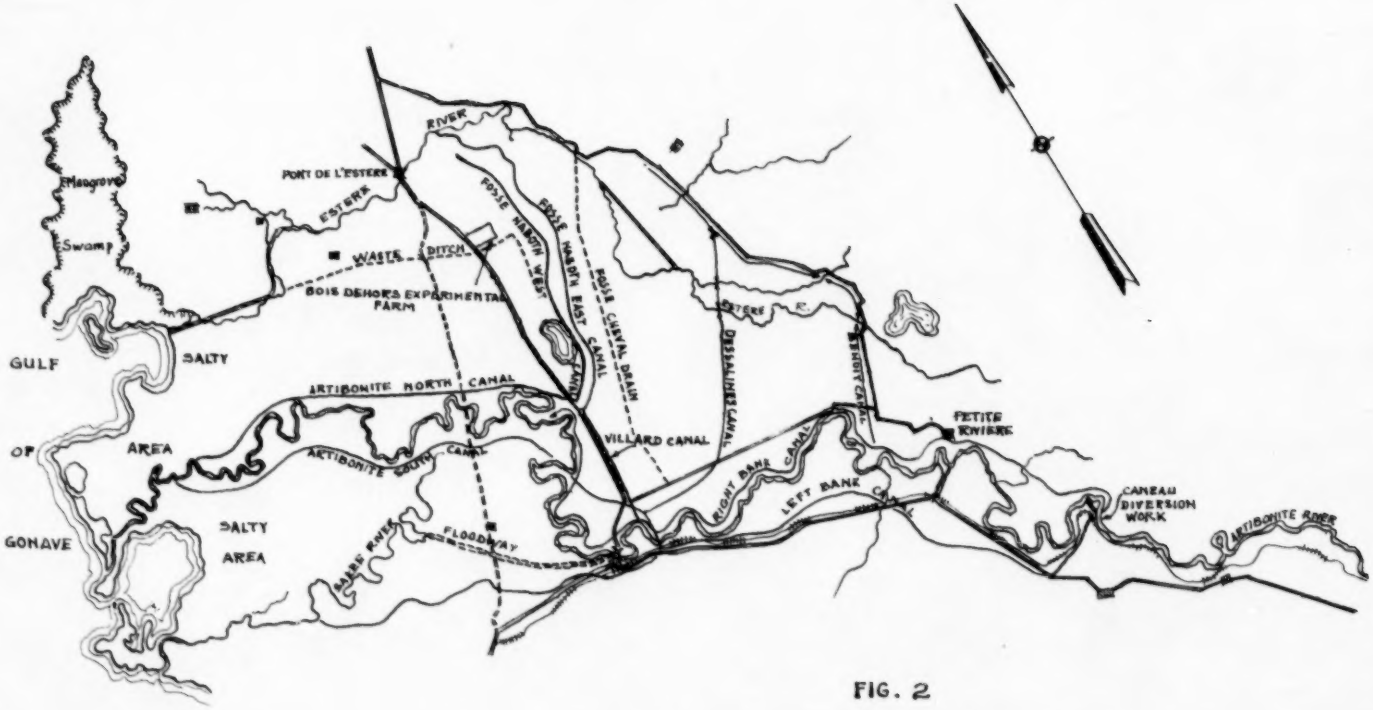

FIG. 2

ARTIBONITE VALLEY IRRIGATION PLAN

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